TITLE OF INVENTION

APPARATUS AND METHOD TO ENHANCE DECONTAMINATION OF FINE-GRAINED SOIL PARTICLES

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Filed:

A METHOD AND APPARATUS TO ENHANCE DECONTAMINATION OF VERY-FINE-GRAINED SOIL PARTICLES

BACKGROUND OF THE INVENTION

1. Field of the Invention.

This invention relates to decontamination of fine-grained soil particles and is more particularly concerned with an improved apparatus for subjecting very fine-grained soil particles to a very high level of kinetic energy in a continuous multi-stage washing process within a multi-faceted enclosure designed to control the expansion of turbulence and maintain the velocities of the particles in the admixture to maximize inter-particle shear and washing.

2. Description of the Prior Art.

Environmental concerns of our society have caused the development of various methods for the purpose of washing contaminants from soil particles. Some of said methods utilize spray-washing of soil particles on moving or rotating screens; turbulence-producing propellers or paddle systems in slurries of soil particles; jets at the surface of slurries in tanks or jets submerged in slurries of soil particles and the like. All of the foregoing methods and others are work-and-time-intensive as the concentration of contaminants is sought to be reduced to environmentally acceptable standards. The practice of spray-washing soils on screens encounters problems such as washing fluids by-passing soil particles, upper layers of soil particles shielding lower layers, high fluid-volume requirements with attendant dirty-fluid disposal problems, extensive equipment costs, fluid-recycling requirements to reduce contaminants concentration and the like. The many uses of turbulence-producing devices such as rotating paddles or propellers in baffled tanks are limited in their abilities to generate high-velocity turbulence to accelerate the admixture and develop shear rates necessary to displace resistant compounds of chemicals, metals, hydrocarbons, radioactive substances, and the like from fine-grained soil particles. One of the limiting factors in the use of rotary washing devices, i.e. propellers, is the cavitation attending high-speed rotation. Cavitation results in wasted energy, excessive equipment maintenance, noise, vibration, and the like, and it still falls short of efficiency. Other methods have been employed such as jetting into open-top tanks and also the use of submerged jets. In either case, the turbulent plume of admixture discharged from said jet

dissipates very quickly in the fluid media being treated due to the expansion of the incoming stream and the resistance of the fluid the jet stream is entering. The attendant dissipation of the incoming jet-stream velocity deprives said stream of the kinetic energy therein and thus the capability of the washing-fluid stream to create the shear required to remove tenacious contaminants from fine-grained soil particles. A great deal of research has been conducted to gain understanding of fluid jets entering fluids. One of the problems accompanying the use of jets in fluid media is the creation of streamlines paralleling the path of the jet stream. Said streamlines characteristically create conditions of minimal shear due to low-particle-relative-velocity, fluid cushioning and adhesive drag between constituents. Further, energy dissipation in the incoming jet stream is due to the turbulent "cloud" it creates while expanding and simultaneously rapidly loosing its velocity and, therefore, its kinetic energy and shearing ability to remove contaminants from fine-grained soil particles.

Fine-grained soil particles are very resistant to washing by any of the foregoing methods. All of the problems described above are compounded as grain size diminishes. Larger particles in fluid media have adequate mass and, therefore, adequate inertia to resist-to some degree-the drag forces in a moving stream of washing fluid. As a result the surfaces of particles greater than 2,000 microns in diameter, for example; experience shear forces from moving wash water that can remove minute quantities of contaminant from the particles surfaces because the larger particles have some inertial resistance to movement by turbulent wash water. In contrast to the response of larger particles, i.e. particles having diameters greater than 2,000 microns, particles of less than 2,000 microns can be displaced more readily by particles of wash water and thus the shearing effect on the smaller particle's contaminants is reduced. As the soil particle diameter decreases its mass will also generally decrease and, therefore, its inertia decreases and it becomes more easily moved by a particle of wash fluid. Thus the shearing effect of a moving particle of wash water is diminished. The removal of contaminants from soil particles ranging between 20 and 500 microns in diameter becomes exceedingly difficult due to their small mass and low inertia and their susceptibility to being moved by the wash fluid. Also many of the problems encountered by conventional soil washing methods result from the adhesive forces between the soil particles and the contaminants thereby making their removal from the soil particle a difficult task. Cohesive forces between particles of contaminant also contribute further to the difficulties encountered by conventional soils washing methods. Of no small concern in conventional soil

washing activities is the generation of voluminous quantities of dirty water containing minute quantities of removed contaminants. Said dirty water cannot be reused until it has been filtered and itself decontaminated. The physical plant in many cases is quite large, cost intensive, and expensive to operate. A major advantage of this invention is the efficient use of high levels of kinetic energy in smaller volumes of high-velocity wash fluid instead of the conventional use of low kinetic energy, low velocity, and high volumes of wash fluid because treating and cleaning large volumes of wash fluid is a major operating expense. It has been found that many of the problems hither to encountered in the art of soil washing can be reduced or eliminated using the apparatus and process described hereinafter.

SUMMARY OF THE INVENTION

This invention comprises an apparatus and a method for improving decontamination of very-fine-grained soil particles by overcoming several of the above-mentioned problems now complicating conventional methods of washing resistant chemical, metallic, hydrocarbon, and radioactive contaminants from very fine-grained soil particles.

Said invention provides means for improved efficient use of kinetic energy in a washing fluid by restricting movement of slurried, contaminated admixture within a multi-faceted washing chamber while repetitiously subjecting said particles of said slurry to extreme shear with very-high-velocity wash fluid wherein expansion of turbulence is strictly limited to achieve an efficient high-kinetic energy, continuous washing process which includes no moving parts and uses only the flow of the admixture through said apparatus to accomplish said desired decontamination of fine-grained soil particles.

BRIEF DESCRIPTION OF THE DRAWINGS

One embodiment of the invention has been chosen for purposes of illustration and description and is shown in the accompanying drawings forming a part of the specification wherein:

Figure #1: Is a perspective representation in cross section of a side elevation of one half of one embodiment of an apparatus for washing tenacious contaminants from fine-grained-soil particles in accordance with the invention. The other half is a mirror image of Fig. 1.

Figure #2: Is a schematic diagram showing a soil-washing system depicting the high-shear washing device employing the present invention 11, slurry tank 23, washing-fluid tank 3, slurry transfer conduits 4, washing-fluid transfer conduits 10, high-pressure washing-fluid pump 25, dirty water and cleaned soils discharge conduit 12, dirty-water and soil-separation 18, cleaned soils to land fill 19, cleaned wash water to be recycled 20, wash water return conduit 22 to supply tank 3.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to Fig. #1 of the drawings, there is shown one half of an apparatus in accordance to be used for washing contaminants from fine-grained-soil particles. Fig. #1 is the invention mirror image of the other half of the apparatus.

The apparatus includes an enclosure having a rectangular body portion **1** defined by external wall surface **2** and internal passages **14** and **15** machined into said metal body which is constructed in two matching halves only one of which is shown. The two halves are assembled for operation by bolting them together in alignment using commercially available bolts, not shown, through holes **5** prepared for same. The metal body **1** is constructed with means to receive commercially available high-pressure fluid conduits **10**, Fig. #**2** assembled into said metal body at threaded inlet openings **6**. Said high-pressure fluid (2,000 psi) conduits are supplied with high–pressure wash fluid by a commercially available pump **25**, Fig. #**2** rated to deliver the fluid volume and pressure required for the specified process.

Four slots **7** provide means for feeding low–pressure contaminated slurry into said internal passages **15** at an angle of 90°. Said low-pressure contaminated slurry combines with and is washed by high-velocity wash fluid supplied through inlets **6** and nozzles (commercially available, not shown) at position **24**. Said low-pressure slurry entering passages **14** through slots **7** will hereinafter be referred to as the "secondary streams" and said high-pressure, high-velocity fluid entering passage **15** through said nozzles at position **24** will be referred to as "primary streams". Said secondary streams enter said primary streams with minimum consumption of the kinetic energy in said primary streams as said primary streams contact and accelerate said secondary streams down passages **15** toward a faceted washing chamber **16**. The contact between the said primary and said secondary streams at the internal opening of passages **14** is the first of five stages of high-velocity, high-shear washing to take place within the device.

Said secondary streams of slurry entering passages **14** through slots **7** are provided from a slurry tank **23**, Fig. #**2** at low-pressure via commercially available piping means **4**, Fig. #**2** attached to said steel washer body by welding. Said high-pressure fluid conduits (commercially available) attached to said steel body **1** at openings **6** are fitted with commercially available piping and sealing devices such as "o" rings (not shown) which seal against commercially available nozzles (not shown) seating against retaining flanges **9** machined into said steel body **1**. Said nozzles discharge primary streams of high-velocity wash fluid into said primary passages

15. Said primary streams contact at 90^{o} angles said secondary streams entering said primary passages 15 through secondary passages 14. Said contact of said primary streams with said secondary streams is the first of five washing stages designed into the device as will be explained later.

Said primary streams accelerate said secondary streams to a velocity of approximately 500 to 600 feet per second into entrance 13 of the faceted washing chamber 16 from each end of primary passage 15. The relative velocity of the two primary streams with respect to each other approximates 1200 feet per second as they enter said faceted washing chamber 16 at position 13. At position 13, the entrance to said faceted washing chamber 16 said incoming streams of high-velocity admixture of said wash fluid and said slurry particles commingles with turbulent admixture that has previously entered said faceted washing chamber 16 in high-shear washing-stage number two of the process. As said incoming admixture of said primary and said secondary streams continues from entrance 13 of said faceted washing chamber 16 on into said chamber 16, washing stage number three takes place as said two incoming streams of admixture meet in said faceted washing chamber under high-shear conditions at a combined velocity approaching 1200 feet per second. At this point in the process said incoming admixture still retains much of said kinetic energy it contained upon entering said faceted washing chamber at a downward angle of approximately 10^{o}. Said downward orientation of passages 15 has the dual purpose of causing said incoming, high-velocity streams to deflect each other away from exit 8 to prevent premature escape of said admixture through said exit 8 and also to cause said incoming streams of admixture to be deflected to and impinge on the multi-faceted bottom surfaces 18 of said washing chamber. Said admixture then ricochets upward through violent turbulence and shear at various angles into and through the paths of said admixture entering said washing chamber 16 from passages 15 in area 21 in what is designated as washing stage five. Said decontaminated admixture now exits said washing chamber 16 through exit opening 8 where it is conducted by suitable commercially available conduit to final filtration, rinsing and removal of the fine-grained solids (now decontaminated) and treatment of said wash fluid for recycling.

The result of the efficient usage of the kinetic energy in high-velocity washing within this energy-conserving device results in removal of said resistant contaminants from said fine-grained soil particles with the generation of much less dirty water to filter and neutralize. Other

major benefits from using said subject invention are lesser capital investment, less operating personnel, fewer problems in disposal of washed solids, portability and versatility.

Although said invention has been described in conjunction with said foregoing specific embodiment, many alternatives, variations and modifications will be apparent to those of ordinary skill in the art. These alternatives variations and modifications are intended to fall within the spirit and scope of the appended claims.